

**DEVELOPMENT OF TITANIUM DIOXIDE
NANOPARTICLES/NANOSOLUTION FOR PHOTOCATALYTIC
ACTIVITY**

by

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**Thesis submitted in fulfilment of the
requirements for the degree of
Doctor of Philosophy**

JUNE 2015

ACKNOWLEDGEMENTS

Firstly, I would like to express my deepest gratitude to my supervisor Assoc. Prof. Dr. Ir. Srimala Sreekantan for her expert guidance, constant attention, valuable suggestions, enthusiastic support and personal concern during the research and through the course of my study. Her fruitful ideas throughout the research project has helped me accomplished this work successfully.

Special thanks to the Dean of School of Material and Mineral Resources Engineering, Professor Hanafi Ismail for his permission to let me use all the brilliant facilities and equipment in completing my project. Under his leadership, he has created a healthy learning environment in the school. I would also like to extend my sincere appreciation to thank the technical staffs of School of Materials and Mineral Resources Engineering, especially to Mdm. Fong Lee Lee, Mrs Haslina, Mr. Azrul, and Mr. Zulkurnain for their various contributions in one way or another.

To my dear friends and labmates, Norwanis, , Suhaina, Khairul Arifah, Nur Hidayati, Syahriza and all close members of postgraduate room of School of Materials and Mineral Resources Engineering, thank you for making my life in USM so colourful and enjoyable. Last, but not least to my family especially to my ever-loving mother whom are always on my side, Hajjah Rinah Binti Mohd. Jirin, Thank you for the support and the encouragement you gave me to pursue my dreams. Not to forget, my family members who always be there for me through my thick and thin.

Siti Aida Ibrahim

June 2015

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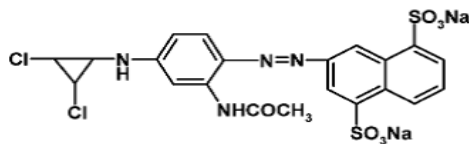
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LIST OF ABBREVIATIONS

REHDA	Real Estate House Development Association
NP	nanoparticles
NS	nanosolution
NT	nanotube
IAQ	Indoor air quality
IAP	Indoor air pollution
CB	Conduction band
VB	Valence band
PCA	Photocatalytic activity
ROS	Reactive oxygen species
MO	Methyl Orange
MB	Methylene Blue
Rh.B	Rhodamine B
TTIP	Titanium(IV) isopropoxide
IP	2-propanol/ Isopropanol
DI	Deionized water
ESR	Electron spin resonance
CO ₂ -TPD	CO ₂ - temperature programmed desorption
VOC	Volatile Organic Compound
TVOC	Total Volatile Organic Compound
BET	Brunauer-Emmet-Taylor
FESEM	Field Emission Scanning Electron Microscopy
XRD	X-ray Diffraction Spectroscopy
TEM	Transmission Electron Microscopy

HRTEM	High Resolution Transmission Electron Microscopy
PL	Photoluminescence
UV-Vis	Ultra Violet-Visible
XRG	Organic dye with yellow colour. The molecular structure of XRG is as below



LIST OF SYMBOLS

%	Percentage
<	Less than
>	More than
°	Degree
°C	Degree Celsius
°C/min	Degree Celsius per minute
T	Temperature
L	Litre
m	Meter
cm	Centimetre
mL	Millilitre
mm	Millimetre
nm	Nanometer
wt %	Weight percent
at.%	Atomic percent
mmol	millimoles
g	Gram
λ	Wave length
h	Hour
min	Minute
s	Second

LIST OF PUBLICATIONS & AWARDS

Publications

1. IBRAHIM, S. A. & SREEKANTAN, S (2011). Effect of pH on TiO₂ Nanoparticles via Sol-Gel Method. *Advanced Materials Research*, 173, 184-189.
2. IBRAHIM, S. A., RIDHUAN, N. S. & SREEKANTAN, S. of methyl orange using TiO₂ as photocatalyst. AIP Conference Proceedings, 2011. 123-127.
3. IBRAHIM, S. A. & SREEKANTAN, S.(2010). Effect of annealing atmosphere towards TiO₂ nanoparticles on their photocatalytic performance in aqueous phase. *Proceeding of International Conference on Enabling Science and Nanotechnology (ESciNano 2010)*, 1- 3rd December 2010, Kuala Lumpur, Malaysia
4. IBRAHIM, S. A. & SREEKANTAN, S. (2014). Fe-TiO₂ Nanoparticles by Hydrothermal Treatment with PCA Enhancement. *Advanced Materials Research*. 1024, 39-43.
5. IBRAHIM, S. A. & SREEKANTAN, S. (2015). Effect of Fe Incorporation on the Photocatalytic Activity of TiO₂ by Sol-Gel Method. *Advanced Materials Research*. 1087, 218-222.

Award

1. The Silver Medal, Korea International Women's Invention Exposition (KIWI) 2012, Seoul, Korea, 3-6 May 2012 for project entitles: SMARTCOAT: Remedy for VOC, Bacteria and Fungi growing world.
2. The Gold Medal, The British Invention Show (BIS) 2012, London, UK, 24-27 Oct 2012, for project entitle: SMARTCOAT-for natural earth category
3. The Gold Medal, The British Invention Show (BIS) 2012, London, UK, 24-27 Oct 2012, for project entitle: SMARTCOAT-for consumer category
4. The Gold Medal, National Research & Innovation Competition 2012, 17 - 19th July 2012, for project entitle: NANOCOAT: An Inspired Molecular Solutions for ultimate protection against indoor air pollutants
5. The Gold Medal, Malaysia Technology Expo 2013, 21-23rd Feb 2013, for project entitle: SMARTCOAT: Remedy for VOC, Bacteria and Fungi growing world.

PEMBANGUNAN TITANIUM DIOKSIDA NANOZARAH/LARUTAN-NANO UNTUK AKTIVITI FOTOPEMANGKIN

ABSTRAK

Bahan pencemar biologi dan kimia oleh aktiviti buatan manusia telah menjadi isu global yang serius. Pendedahan kepada bahan pencemar ini yang melebihi had boleh menyebabkan masalah alam sekitar dan kesihatan yang serius. Oleh itu, pembangunan penyelesaian berkesan yang boleh digunakan oleh manusia sejagat adalah penting. Salah satu cara berkesan untuk mengatasi masalah ini ialah dengan menggunakan titanium dioksida (TiO_2). TiO_2 adalah fotopemangkin yang diketahui umum dan digunakan dengan meluas bagi tujuan pembersihan alam sekitar disebabkan oleh keupayaannya untuk menguraikan bahan cemar organik dan membunuh bakteria. Walaupun TiO_2 terbukti mempunyai kelebihan untuk menyelesaikan masalah ini, akan tetapi kebergunaannya terhad hanya kepada penyinaran cahaya UV. Oleh itu, tujuan kajian ini adalah untuk menyiasat potensi TiO_2 yang boleh diaktifkan dalam cahaya nampak dengan gabungan ion logam (Fe, Ag, Zr dan Ag-Zr). Dalam kajian ini, kaedah sol-gel digunakan untuk mensintesis TiO_2 yang digabungkan dengan ion logam. Analisis XRD menunjukkan semua sampel mempunyai anatas-brukit TiO_2 dwifasa dengan saiz 3 nm hingga 5 nm. Penggabungan ion-ion logam didapati tidak mengubah morfologi TiO_2 tetapi mempunyai kesan terhadap ciri-ciri kehabluran dan optik. Kehabluran anatas bagi TiO_2 dwifasa didapati berkurangan dan pembentukan brukit diutamakan. Analisis PL menunjukkan penggabungan dengan ion-ion logam menghalang penggabungan semula pasangan elektron-lubang manakala tenaga sela jalur bagi TiO_2 (3.2 eV) berkurangan apabila digabungkan dengan Fe (2.46 eV) dan Ag (2.86 eV). Antara

penggabungan ini, Ag-Zr yang digabungkan dengan TiO_2 menunjukkan prestasi tertinggi bagi degradasi metil jingga (93%) di bawah penyinaran cahaya pendarfluor selama 10 jam. Ini diikuti oleh Zr- TiO_2 (82%), Fe- TiO_2 (75%) dan Ag- TiO_2 (43%). Sementara itu, prestasi antibakteria tertinggi ditunjukkan oleh Ag- TiO_2 . Imej TEM menunjukkan bakteria *E.coli* dibunuh dalam jangka masa 12 jam selepas dirawat menggunakan Ag- TiO_2 . Keputusan yang diperoleh daripada kajian kerja lapangan membuktikan bahawa penggabungan dengan Ag-Zr mempunyai prestasi yang cemerlang bagi penyingkiran sebatian organik mudah meruap (VOC) dan ujian antibakteria. Kandungan VOC setelah dirawat oleh Ag-Zr- TiO_2 memenuhi Tataamalan Industri Kualiti Udara Dalaman 2010, iaitu lebih rendah daripada 3 ppm. Di samping itu, peratusan mikrob juga didapati berkurangan sekitar 45% dalam tempoh pemerhatian selama 5 hari.

**DEVELOPMENT OF TITANIUM DIOXIDE
NANOPARTICLES/NANOSOLUTION FOR PHOTOCATALYTIC
ACTIVITY**

ABSTRACT

Biological and chemical contaminants by man-made activities have been serious global issue. Exposure of these contaminants beyond the limits may result in serious environmental and health problem. Therefore, it is important to develop an effective solution that can be easily utilized by mankind. One of the effective ways to overcome this problem is by using titanium dioxide (TiO_2). TiO_2 is a well-known photocatalyst that widely used for environmental clean-up due to its ability to decompose organic pollutant and kill bacteria. Although it is proven TiO_2 has an advantage to solve this concern, its usefulness unfortunately is limited only under UV light irradiation. Therefore, the aim of this work was to investigate the potential of TiO_2 that can be activated under visible light by the incorporation of metal ions (Fe, Ag, Zr and Ag-Zr). In this study, sol-gel method was employed for the synthesis of metal ions incorporated TiO_2 . XRD analysis revealed that all samples content biphasic anatase-brookite TiO_2 of size 3 nm to 5 nm. It was found that the incorporation of these metal ions did not change the morphology of TiO_2 but the crystallinity and optical properties were affected. The crystallinity of anatase in the biphasic TiO_2 was found to be decreased and favored brookite formation. PL analysis showed metal ions incorporation suppressed the recombination of electron-hole pairs while the band gap energy of TiO_2 (3.2 eV) was decreased by the incorporation of Fe (2.46 eV) and Ag (2.86 eV). Among this incorporation, Ag-Zr incorporated TiO_2 showed highest performance for methyl orange degradation (93%) under fluorescent

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